

IN THE CLAIMS

What is claimed is:

1. A method for making a semiconductor device comprising:
5 forming on a substrate a high-k gate dielectric layer;
forming a capping layer on the high-k gate dielectric layer;
oxidizing the capping layer to form a capping dielectric oxide on the high-k
gate dielectric layer; and then
forming a gate electrode on the capping dielectric oxide.
- 10 2. The method of claim 1 wherein the high-k gate dielectric layer is formed
by atomic layer chemical vapor deposition, and wherein the high-k gate dielectric
layer comprises a material selected from the group consisting of hafnium oxide,
hafnium silicon oxide, lanthanum oxide, zirconium oxide, zirconium silicon oxide,
titanium oxide, tantalum oxide, barium strontium titanium oxide, barium titanium
15 oxide, strontium titanium oxide, yttrium oxide, aluminum oxide, lead scandium
tantalum oxide, and lead zinc niobate.
3. The method of claim 1 wherein the capping layer comprises silicon.
4. The method of claim 3 wherein the capping layer is less than about five
monolayers thick.
- 20 5. The method of claim 4 wherein the capping layer is oxidized using a
plasma enhanced chemical vapor deposition process which comprises exposing
the capping layer to ionized oxygen species that were generated by a plasma
source.

6. The method of claim 4 wherein the capping layer is oxidized by exposing the capping layer to a solution that comprises an oxidizing agent.
7. The method of claim 6 wherein the oxidizing agent comprises hydrogen peroxide.
- 5 8. The method of claim 7 wherein the gate electrode comprises polysilicon.
9. The method of claim 8 further comprising applying a wet chemical treatment to the high-k gate dielectric layer to remove impurities from that layer and to increase the oxygen content of that layer prior to forming the capping layer on the high-k gate dielectric layer.
- 10 10. A method for making a semiconductor device comprising:
- forming on a substrate a high-k gate dielectric layer;
- forming on the high-k gate dielectric layer a capping layer that is less than about five monolayers thick;
- oxidizing the capping layer to form a capping dielectric oxide on the high-k
- 15 gate dielectric layer; and then
- forming a layer that comprises polysilicon on the capping dielectric oxide.
11. The method of claim 10 wherein the high-k gate dielectric layer is formed by atomic layer chemical vapor deposition, and is between about 5 angstroms and about 40 angstroms thick.
- 20 12. The method of claim 11 wherein the high-k gate dielectric layer comprises a material selected from the group consisting of hafnium oxide, zirconium oxide, titanium oxide, and aluminum oxide.

13. The method of claim 12 wherein the capping layer comprises silicon and is oxidized using a plasma enhanced chemical vapor deposition process which comprises exposing the capping layer to ionized oxygen species that were generated by a plasma source.

5 14. The method of claim 12 wherein the capping layer comprises silicon and is oxidized by exposing the capping layer to a solution that comprises hydrogen peroxide.

15. A method for making a semiconductor device comprising:

forming a high-k gate dielectric layer on a substrate, the high-k gate
10 dielectric layer being less than about 60 angstroms thick and comprising a material selected from the group consisting of hafnium oxide, zirconium oxide, titanium oxide, and aluminum oxide;
forming on the high-k gate dielectric layer a silicon containing layer that is less than about five monolayers thick;
15 oxidizing the silicon containing layer to form a silicon dioxide layer on the high-k gate dielectric layer;
forming a layer that comprises polysilicon on the silicon dioxide layer; and
etching the polysilicon containing layer, the silicon dioxide layer and the high-k gate dielectric layer.

20 16. The method of claim 15 wherein the high-k gate dielectric layer is formed by atomic layer chemical vapor deposition and is between about 5 angstroms and about 40 angstroms thick.

17. The method of claim 16 wherein the silicon containing layer is oxidized using a plasma enhanced chemical vapor deposition process which comprises exposing the silicon containing layer to ionized oxygen species that were generated by a plasma source.

5 18. The method of claim 16 wherein the silicon containing layer is oxidized by exposing the silicon containing layer to a solution that comprises hydrogen peroxide.

19. The method of claim 18 wherein the silicon containing layer is exposed to a solution that comprises hydrogen peroxide at a temperature that is between
10 about 15°C and about 40°C for at least about one minute.

20. The method of claim 15 further comprising applying a wet chemical treatment to the high-k gate dielectric layer to remove impurities from that layer and to increase the oxygen content of that layer prior to forming the silicon containing layer on the high-k gate dielectric layer.

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